Center Innovation Fund: ARC CIF

Encapsulation Technology for Delivery of Medical Therapeutics

Completed Technology Project (2011 - 2012)

Project Introduction

The NASA Biocapsule technology is a novel drug deilivery system that uses living cells contained in a specialized biocompatible container that can be implanted into the body of a patient. The cells inside the capsule are enigneered to produce a therapeutic peptide or protein, and this product gets released by the cells inside the capsule. The therapeutic product exits the capsule via pores in the wall of the capsule, and gains acess to the circulation or a localized tissue space, in order to exert its therapeutic effect. The biocapsule concept is envisioned for therapeutic applications where long-term release of a therapeutic product is desirable, and for applications in which triggered release of a product is needed, to permit immediate response to an abrupt change in physiological conditions. The technology is geared for NASA medical needs on long-duration space missions and for a wide range of terrestrial medical needs. The technology is designed to bring the potential of synthetic biology to the realm of medical therapeutics, in a way that is safe for patients.

Approach. The NASA Biocapsule technology is made possible by a specialized nanomaterial called Buckypaper, which forms the wall of the biocapsule. Buckypaper is made from carbon nanotubes (either single-walled carbon nanotubes or multi-walled carbon nanotubes) fashioned into a meshwork material. The mesh structure of Buckypaper means that the material is porous. The pores measure approximately 50 nm in diameter, depending on the density of the deposited carbon nanotubes, which is ideal for allowing small to medium size proteins to pass (up to 50,000 Daltons), while preventing cells (typically 7-25 microns in diameter) from passing. Another important feature of Buckypaper is biocompatibility. Since they are made of pure carbon, the carbon nanotubes that make up Buckypaper are biologically inert, which means that they do not elicit a host immune response. Buckypaper is therefore an ideal material for the wall of the biocapsule. When fashioned into closed cylinders, Buckypaper effectively isolates or "shields" the cells inside from the host immune system, but the pores of the Buckypaper allow small to medium sized molecules to pass. By keeping the capsule diameter to 1 mm or less, metabolites and oxygen molecules can cross the biocapsule wall and diffuse to the cells, which keeps the cells healthy. Trigerring molecules, which can be used to "turn on" or "turn off" the cells inside, can also cross the biocapsule wall and get access to the cells. Small to medium molecules that are produced by the cells inside the biocapsule and are secreted by these cells can cross the biocapsule wall, to gain access to the circulation or to a localized tissue bed, depending on the site of implantation. Effort on this project has primarily been directed at refining the fabrication procedures for the NASA Biocapsule, including techniques to ensure uniform deposition of the carbon nanotube meshwork. The quality of the carbon nanotube depostion process is an important determinant of the distribution of pores of the biocapsule wall. The pore distribution must be optimized to ensure that therapeutic molecules can cross the biocapsule wall efficiently. In

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Table of Contents

Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Lead Center / Facility:

Ames Research Center (ARC)

Responsible Program:

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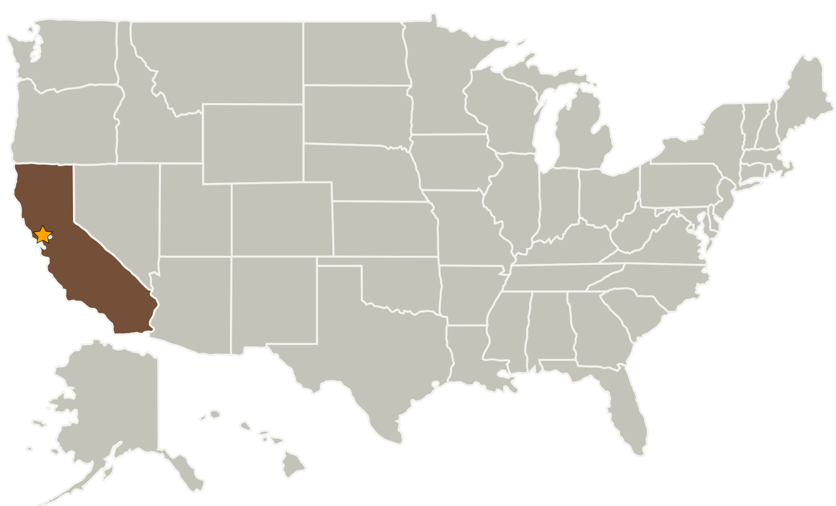
addition, the biocapsule wall must be free of defects, so that host immune system cells do not penetrate the biocapsule to reach the cells inside the capsule, and to ensure that the biocapsule maintains integrity for long-duration implantation. This engineering effort is a necessary pre-requisite before studies can be undertaken in experimental animal systems. Animal studies will examine the flux of therapeutic molecules aross the capsule wall and their pattern of distribution in the body. Continued evalaution of biocapsule biocompatability, biofouling and biocapsule integrity will be a part of these animal studies.   Relevance and Impact. If successful, the project will open up a whole new approach for delivery of protein therapeutic agents via implanted devices, a field that has been stymied for many years by lack of a suitable encapsulation material (lack of biocompatibility; lack of sufficient flux across the capsule wall). Success will also mean a significant advancement of NASA's vision of technology for autonomous medical care on long-duration space missions. Initially, the primary impact will be in the area of medical care for treatment of space radiation illness, the #1 area of health concern for long-duration space flight. Ultimately, however, we view this as a platform technology, that will provide NASA with a tool for addressing a wide range of physiological changes associated with deep space travel. Both countermeasure agents (designed to prevent medical problems) and therapeutic agents (designed to deal with medical problems) may be delivered by the NASA Biocapsule system. Other applications outside the medical field are also envisioned.

Anticipated Benefits

N/A

Primary U.S. Work Locations and Key Partners



Project Management

Program Director:

Michael R Lapointe

Program Manager:

Harry Partridge

Project Manager:

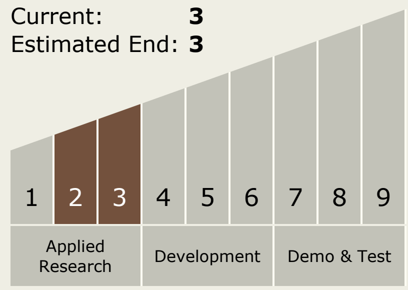
David J Loftus

Principal Investigator:

David J Loftus

Technology Maturity (TRL)

Start: **2**
Current: **3**
Estimated End: **3**



Technology Areas

Primary:

- TX12 Materials, Structures, Mechanical Systems, and Manufacturing
  └ TX12.5 Structural Dynamics
    └ TX12.5.1 Loads and Vibration

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Organizations Performing Work	Role	Type	Location
★Ames Research Center(ARC)	Lead Organization	NASA Center	Moffett Field, California

Primary U.S. Work Locations
California

Stories

1676 Approval #17536
(https://techport.nasa.gov/file/8731)